chorology, according to the particular aspect of the subject under consideration. On the other hand, the interests of all these various sciences are slowly but surely converging to a point which is not far from the center of gravity of 'ethology.' This is apparent in the 'types' and 'habitus' of the systematist and morphologist, in the conceptions of the 'individual,' in experimental embryology and the study of growth and regeneration, in the conceptions of 'adaptivity' among the 'neovitalists,' in the mystic zoology of a Maeterlinck, in the theories of 'determinate variations' and 'orthogenesis,' in recent experimental work on the origin of mutations, etc. In all this work there is apparent a turning away from the 'mechanical' and 'environmental,' a realization of the prematureness and inadequacy of all biological 'explanations' couched in terms of *existent* chemistry and physics, and an appreciation of greater depth and mystery in the life activities than had been previously conceded.

So numerous are the signs of the time that it requires little prophetic insight to discern that we are on the eve of a renascence in zoology. There have been voices crying in the wilderness for many years, and it may be well to hark back to some of these and catch the full force of their intention. First there was Goethe, who glowed with the magnificence of the problem:

"Was ist doch ein Lebendiges für ein köstliches, herrliches Ding! wie abgemessen zu seinem Zustande, wie wahr, wie seiend!"

Then there was the father of developmental science, Karl Ernst von Baer, who began to doubt whether the field he had himself cultivated with such success would yield more than a small portion of the desired harvest:

"Wissen möchten wir ob das 20. Jahrhundert nicht, wenn man die Kunst *das Leben im Leben* zu beobachten, wieder gelernt hat, über die Selbstzufriedenheit des 19. lächeln wird, mit der es glaubt, aus dem Leichnam das Leben in seiner ganzen Fülle erkennen zu können, fast vergessend, dass mit dem bildenden Leben ein handelndes innig verbunden ist, das dem Messer und dem Mikroskop sich entzieht."

And among the latest there is Jules Fabre, indefatigable observer and incomparable writer, who points to the old, sure method of all science as *the* method of 'ethology':

"Large part faite à l'anatomie, précieuse auxiliaire, que savons-nous de la bête? A peu près rein. Au lieu de gonfler avec ce rien d'abracadabrantes vessies, glanons des faits bien observés, si humbles soient."

William Morton Wheeler.
Austin, Texas,
May 17, 1902.

THE LAW OF VON BAER.

BASED ON SCHOLION V.

The writings of von Baer have been subject to much interpretation, and have yielded under the nursing hand of 'productive' scholarship, meanings which in reality they do not contain. It seems therefore worth while to reconsider what is the great generalization at which he arrived; and to those interested in the historical side of embryology, this attempt to follow the reasoning of a masterly investigator may be not unwelcome.

I.

THE PREVAILING VIEW THAT THE EMBRYO PASSES THROUGH THE ADULT STAGES OF LOWER ANIMALS.

At the time when the first volume of the 'Observations and Reflections on the Development of Animals' was published (1828), no propositions in embryology en-

joyed wider acceptance than these: That higher animals in their development from the first beginnings correspond, stage for stage, with the adult condition of lower; that the development of the individual takes place according to the same laws as that of the series; that the more highly organized ones pass in general through the adult stages of those less highly organized, so that the differences between the stages in individual development, may be referred back to the differences between persisting adult forms.

These opinions, born of the time when, excepting Malpighi and Wolff, no one had studied connectedly the earlier periods in the history of the development of any animal, could not fail to excite interest; particularly since by their aid certain malformations could readily be explained as cases arrested in development. The rampant speculations of the Lamarckians derived support from them, but the teachings of this school were as repugnant to von Baer as to many other thoughtful students.

Suppose, he says, that a fish stranded on a sandy beach were seized with the desire to walk, then, according to this school, the fins, unsuited for the perambulatory movements, would promptly shrink in breadth from disuse and in turn grow in length. These modified appendages, transferred to children and grandchildren for several thousand generations, are naturally in the end transformed into feet. Naturally, too, the fish in the meadow gasp for air, and their struggles in the end produce lungs, the only requirement being that a few generations should be exposed to the slight inconvenience of not breathing at all.

The long neck of the heron is due to the fact that his ancestors often stretched that organ in order to catch fish. Their children came into the world with elongated necks and the same evil habit, and thus gave to their offspring necks still longer, from which it follows that if our planet only reaches a ripe old age, the heron's neck will extend beyond the bounds of certain knowledge.

II.

DOUBTS AND OBJECTIONS.

(*a*) At an early time von Baer saw that the relationships between different animals could not be looked upon as representing a steady advance, which is a necessary corollary of the propositions he has set out to criticise. Above all, suspicions were generated from the fact that until that time only the development of the higher forms was known, and this incompletely. What differences their embryonic history exhibited must, if they were to find analogies anywhere, find them among the lower animals. Indeed, resemblances between the embryonic condition of certain animals, and the adult stages of others, seemed to von Baer quite necessary and without significance, since they all fall within the realm of the animal kingdom, and the variations of which the animal body is capable are determined in each case by the interrelations of the separate organs, and in these interrelations, repetitions necessarily occur.

If birds had studied their own embryonic history, and were now engaged in unraveling the structure of adult mammals and man, would not their text-books read as follows:

Those four- and two-legged animals have similar embryos, for the bones of their skulls are separate and they have no bills, as we have after five or six days of incubation. Their extremities are all pretty much alike, about the same in length as our own; not a single true feather adorns their bodies, but only a thin down, in which respect our very nestlings surpass them. Their bones are not very brittle and contain (as ours do in youth) no air; indeed,

they have no air sacs at all and their lungs are free in the pleural sacs; they are utterly devoid of a crop, and gizzard and stomach are but indistinctly delimited from one another, a condition ephemeral with us. The nails of most of them are clumsy and broad, as with us before hatching. Of all of them only the bats, which seem to be the most highly developed, possess the ability to fly. And these mammals, who for so long a time after birth are utterly helpless, and who during their whole lives can never raise themselves off the ground, claim to be more highly organized than we.

(*b*) If it were a law of nature that the development of an individual consists in passing through the adult stages of animals less highly developed, it would follow:

1. That no embryo could pass through stages which do not characterize the adult condition of some animal. There are no animals, however, which carry their food around in a yolk sac, and yet from the development of birds and certain mammals, such animals ought, according to the law, to exist.

2. Just as the environment of an embryo is related to the presence of organs which occur in no higher forms, so it makes impossible the passage through certain lower stages. Thus since all the higher embryos are bathed in water, that distinctive characteristic of insects, the tracheæ, can never develop.

3. An embryo, according to the prevailing theory, should resemble in its various stages a lower form, not merely in one particular, but in all. If at the time when the chambers of the heart are not yet separate, and the digits have not yet become distinct, the embryo is said to be in the fish stage, where is the flattened tail and all that makes up a fish and appears so early in its development?

4. There should be no ephemeral organs in lower animals which are permanent in higher ones, but there are many such, to some of which the bird embryologist has already called attention.

5. The organs in the different classes of animals should appear in the same condition in which we find them during the embryonic life of higher ones, but this is scarcely ever so.

6. Those structures found only in higher animals should appear late in their development. This, however, is by no means true. Parts of the vertebral column and the arches of the vertebræ appear in the chick earlier than any other organs. How can the chick ever resemble an invertebrate?

III.

THE RELATIONSHIPS BETWEEN DIFFERENT ADULT ANIMALS.

(*a*) The degree of development of the animal body, and the type of organization, must be clearly distinguished. The degree of development of the animal body consists in a certain amount of heterogeneity in its component parts; in diversity of tissues and of form. The more homogeneous the mass of the body, the lower the degree of development. The fishes, for example, because they have a brain, a cord and a skeleton, and present clearly the vertebrate type, are held to be superior to all invertebrates, and the advocates of the supposed law of development wonder that the bee and most insects with metamorphosis give evidence of greater skill and a more complicated life. In the bee, however, nerves and muscles are developed to such a degree that they differ from each other much more than do the same organs in fishes. Indeed the nerves and muscles of the latter seem to be soggy with the water in which they live.

(*b*) By type of organization is meant the relations existing between the organic

elements and organs on account of their positions in space, and these spacial relations are connected with certain fundamental processes of life, viz., the position of the receptive and excretory poles. Type is thus entirely different and distinct from degrees of development. The same type may be exhibited in several different degrees of development, and conversely the same degree of development may be reached in several different types. The result of a degree of development and the type gives the distinguishing characteristics of a class.

THE DOCTRINE OF TYPES.

According to this doctrine, the animal world presents four fundamental types of organization, the peripheral or radiating type, found in infusorians, medusæ, and asteroids; the segmented or length type, found in worms; the massive type, found in molluscs, and in some radiolarians and infusorians; and finally the vertebrate type, a composite, in which all types are united. Thus the vertebrate brain is built probably after the asteroid type; the viscera are certainly molluscan, and the vertebral column, without doubt, worm-like, though according to the argument in other places, distinctively vertebrate at the same time.

These four fundamental types are capable, by suppression and expansion, of many combinations, and the amount of suppression or preponderance of the different types determines classes, genera, and species. 'If it be true,' von Baer says, 'that the larger and smaller groups of animals depend on this twofold relation, between the degrees of development and the types of organization, then the opinion that there exists an uninterrupted advance from the lower to the higher is based on misconception.'

IV.

APPLICATION OF THE ABOVE DOCTRINE TO THE HISTORY OF INDIVIDUAL DEVELOPMENT.

(*a*) It is clear that a higher or a lower degree of development is the same thing as a greater or less degree of diversity in tissues and in form. The mass out of which an embryo is molded, and the body mass of the simplest animal, are very much alike, for in both there is little distinctness of form, and slight contrast of parts. If therefore we discover in the tissues of some lower animals a greater degree of diversity than in others, and place them in series according to the differences presented, we find many coincidences between the observed facts and the requirements of the genetic law implied by this series.

(*b*) These coincidences between the facts and the theoretical requirements, however, do not show that the embryo of a higher form passes gradually through the adult stages of lower ones. It seems, in fact, as though the type of each animal were immediately impressed upon its embryo, and that this governs its whole development. The history of the chick is a commentary to this statement.

The first organs to be distinguished in the germ are those of the vertebrate type, and it is clear that after their appearance resemblance to an invertebrate can no longer be held. In the beginning of their development, all classes of vertebrates are very similar, and so we can say that the embryo of a vertebrate is from the beginning a vertebrate and has at no time any resemblance to an invertebrate. An adult animal, having the vertebrate type and such slight diversity of tissues and distinctness of form as the vertebrate embryo, is unknown, and so the embryos of vertebrates in their development do not pass through the adult stages of any known animals.

(*c*) 'Is there then no law of individual development?' asks von Baer. He believes there is and bases it on the following considerations:

The embryos of mammals, birds, lizards and snakes present such similarities in their entirety as well as in the development of corresponding parts that except for differences in size it would be difficult to distinguish them.

The further we go back in the history of development, the greater do we find those similarities, and only gradually do those special characters emerge from the general type which distinguishes the smaller groups of animals. To this the history of the chick in every stage of its development bears witness.

In the beginning, when the back closes, it is a vertebrate and nothing more. When the embryo becomes more and more separated from the yolk; when the gill clefts close and when the urinary sac grows out, it becomes a vertebrate unsuited for free life in the water. Only later, a difference in the extremities is recognizable and the bill appears; the lungs move upwards and the air sacs are established as rudiments. Now there is no longer any doubt that the form is a bird. While the avian characteristics become augmented by development of the wings and air sacs, and by the fusion of the carpel cartilages, the webs of the feet disappear and we have a terrestrial bird. Later when the crop is developed and the nasal scale appears, the terrestrial bird takes on the characters of the *Gallinæ* and finally those of the domestic fowl.

(*d*) Briefly, we may say that the point of greatest resemblance in the development of two animals is remote in proportion to the amount of difference they exhibit in their adult condition. The differences between the long-tailed and the short-tailed crabs are not very great. The crayfish has in the middle of its embryonic life a tail short in proportion to the broad sternum, and it is difficult to distinguish at this stage from the short-tailed crabs, which, according to Cavolini's figures, are in their embryonic condition comparatively long-tailed. The further we go back in the history of development, the greater do we find the similarity between the feet and the organs of mastication. We have thus not only an approach to the fundamental type, but a resemblance to the Stomatopoda, the *Amphipoda* and the *Isopoda*, which in their fully developed state differ more from the *Decapoda* than these do among themselves. To this may be added that in the *Decapoda* according to Rathke, the heart appears spindle-shaped, and many other points of similarity, so far unrecognized, must exist. Still earlier, when the feet are present as small laterally budding knobs, and the gills are not yet visible, a resemblance with true insects in their embryonic condition is not to be denied.

These considerations bring us to the question whether there is not, early in the history of development, a stage in which the embryos of vertebrates resemble those of invertebrates. In another place, von Baer shows that even the series of segmented animals begins development with a primitive streak, and that therefore during this brief period there is a resemblance between them and the early stages of vertebrates. In the germ, all embryos developed from a true egg probably resemble each other and in this lies a strong reason for considering the germ as the animal itself.

(*e*) The further back we go in development, the more points in common do we find in very different animals, and so the question arises whether in the beginning all are not fundamentally alike and whether there does not exist a common ancestor. All true eggs appear to have a

distinct sheet-like germ, which seems to be lacking to the germ grains so far as their development is known. These latter are in the beginning solid, but their first act of independent life seems to be a hollowing-out by which they become converted into thick-walled vesicles, observed in the case of *Cercaria* and *Bucephalus*. The germ of a true egg is also to be looked upon as a vesicle, which in the case of birds only gradually grows around the yolk, being supplemented in the beginning by the vitelline membrane. Since, however, the germ is the undeveloped animal itself, we cannot assert, without good reason, that the simple vesicular form is the common ancestor from which all animals are descended. The germ grain goes over into this primitive condition on account of its own inherent power; the egg, only after its female nature has been neutralized by fertilization. Not until this has occurred does the separation into germ and yolk, or body and nutrient stuff, take place.

(*f*) If in order to find resemblance between two animals, we must go back in the history of development a distance proportional to the amount of difference they display in their adult condition, we must recognize as laws of individual development:

1. That those characteristics common to a large group of animals appear earlier in their development than those which characterize the members of the group individually.

2. That from the general, the less general is formed, until what is most special appears.

3. That the embryo of every animal, instead of passing through the adult stages of others lower in the scale, in reality grows increasingly different from these.

4. That the embryo of a higher animal never does resemble the adult of a lower one, but only its embryo.

It is only because the less highly developed animals go little beyond their embryonic condition, that they present certain points of similarity with the embryos of higher forms. These resemblances therefore do not indicate the existence of a limiting condition determining the course of the development of the higher forms, but find their explanation in the organization of the lower ones.

(*g*) These facts are illustrated graphically in a table showing the advance from the lowest grade of development to the highest. From this schema it is clear that an embryo cannot be maintained to pass in its development through the whole series of animals, because it cannot pass from one fundamental type over into another. Then again an embryo in its development does not pass through another form but only through the region of indifference between that form and its own adult condition. Thus the further the development proceeds, the narrower does the region of indifference become. The *schema* also demonstrates that an embryo in the beginning is an indifferent vertebrate, then an indifferent bird, and so on. Since in its progression from one region of indifference to the next it is becoming internally more and more perfect, it is at the same time also becoming a more and more highly developed animal.

The view here advocated differs from the one generally held, in that this is based on an unproved assumption and derives support from the neglect of the important distinction between type of organization and degree of development.

The embryo is gradually formed by progressive diversification of tissues and of form, and for this reason the younger it is, the more nearly does it resemble slightly developed animals. Different animals vary more or less from the basal type which is nowhere pure but occurs

only in definite modifications. Fishes are nearer the type than mammals and especially man. Naturally therefore the embryos of mammals resemble fishes. If we recognize in the fish merely the slightly developed vertebrate (which is the unfounded assumption) we must interpret the mammal as a highly developed fish, and then of course it is consistent to say that the embryo of a vertebrate is at first a fish. For this reason the prevailing view of the law of individual development necessarily implies a progressive series in the animal kingdom. But the fish is more than an imperfect vertebrate. It has undoubted piscan characters as its development abundantly shows, and this development, as in all animals, is governed by two conditions:

1. By progressive diversification of tissues and of form, accompanied,

2. By the passage from a general, indifferent and indefinite state into a definite and particular one.

OTTO C. GLASER.

JOHNS HOPKINS UNIVERSITY.

MEMBERSHIP OF THE AMERICAN ASSOCIATION.

THE following have completed their membership in the American Association for the Advancement of Science during the month of May:

Herman R. Ainsworth, M.D., Addison, N. Y.

Chas. E. Allison, M.D., Elysburg, Pa.

Howard S. Anders, M.D., 1836 Wallace St., Philadelphia, Pa.

Winslow Anderson, M.D., 1025 Sutter St., San Francisco, Cal.

Wm. J. Asdale, M.D., 5523 Ellsworth Ave., Pittsburg, Pa.

Adolph Barkan, M.D., 14 Grant Avenue, San Francisco, Cal.

Guido Bell, M.D., 431 E. Ohio St., Indianapolis, Ind.

J. Mortimer Bessey, M.D., 1814 Adams St., Toledo, Ohio.

Julius C. Bierwirth, M.D., 137 Montague St., Brooklyn, N. Y.

Joseph W. Blankinship, Ph.D., State College, Bozeman, Montana.

Anthony J. Boucek, M.D., 624 Chestnut St., Allegheny, Pa.

Norman Bridge, M.D., 100 Grand Ave., Pasadena, Cal.

Wallace A. Briggs, M.D., 1300 I St., Sacramento, Cal.

George M. Brill, 1134 Marquette Bldg., Chicago, Ill.

Philip K. Brown, M.D., 1303 Van Ness Ave., San Francisco, Cal.

Charles C. Browning, M.D., Highland, Cal.

James I. Buchanan, 6108 Walnut St., Pittsburg, Pa.

W. J. Burdell, M.D., Lugoff, S. C.

Leroy S. Chadwick, M.D., 1824 Euclid Ave., Cleveland, Ohio.

Stanford E. Chaillé, M.D., P. O. Drawer 261, New Orleans, La.

William Cleburne, 1219 South 6th St., Omaha, Nebr.

Thomas U. Coe, M.D., Bangor, Maine.

Wm. H. Coster, Shady Ave., above 5th Ave., Pittsburg, Pa.

H. Holbrook Curtis, M.D., Madison Ave., New York, N. Y.

J. Y. Dale, M.D., P. O. Box 14, Lemont, Pa.

Nathan S. Davis, M.D., 65 Randolph St., Chicago, Ill.

Gordon K. Dickinson, M.D., 278 Montgomery St., Jersey City, N. J.

Wm. S. Disbrow, M.D., 151 Orchard St., Newark, N. J.

George Dock, M.D., 1014 Cornwell Place, Ann Arbor, Mich.

Charles W. Dulles, M.D., 4101 Walnut St., Philadelphia, Pa.

Henry B. Dunham, M.D., State Sanatorium, Rutland, Mass.

Lehman H. Dunning, M.D., 224 N. Meridian St., Indianapolis, Ind.

Lewis L. Dyche, 1611 Mass. St., Lawrence, Kansas.

James B. Eagleson, M.D., 512 Burke Bldg., Seattle, Wash.

Adalbert Fenyes, M.D., P. O. Box W, Pasadena, Cal.

George E. Fisher, University of Pennsylvania, Philadelphia, Pa.

Robert Fletcher, Thayer School of Civil Engineering, Hanover, N. H.